



Rockwell International

**MATERIALS AND PROCESSES  
FAILURE ANALYSIS LABORATORY**

NUMBER PTN 027937

9

**TEST REPORT**

DATE REC'D IN LAB 09-17-92

NOMENCLATURE/SUBJECT Evaluation of Laser Marked Vericodes on Turbine Blade

CONTRACT/LR LR 5941

SPECIFICATION none

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LOCATION AB70

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LABORATORY NOTEBOOK PAGES \_\_\_\_\_

**BACKGROUND**

Vericode marking is under consideration for use in marking Orbiter hardware with pertinent information. The Vericode process uses a two-dimensional binary array to store information. The array is applied to the part via several different techniques, including laser marking.

A segment of a Mar-M-245 cast nickel-based superalloy was submitted to the laboratory which had been Vericode marked in two locations.

**OBJECTIVE**

Determine the physical effects of laser marking on the nickel-based superalloy material.

**INVESTIGATION AND RESULTS**

**Macroscopic Examination**

The overall turbine blade segment is shown in Figure 1. Two Vericode patterns had been laser cut into the part on the ends of the retainer. As shown in Figure 2, each of the Vericode patterns was approximately 2 mm square.

Under stereomicroscopic examination the laser marking appeared to create small overlapping 'dimples'. The pattern of application clearly indicated the direction of application with the overall appearance of the pattern being similar to a TIG weld. Refer to Figure 3.

**Electron Microscopic Examination**

Each of the Vericode patterns was examined in greater detail using the scanning electron microscope (SEM) at magnifications up to 1,000X. The small, overlapping craters created by localized melting are illustrated

in Figures 4 through 7. No distinct cracking could be located on any portion of the Vericode patterns, but small folds of metal were found

along the edge of all laser cut spots. These did not appear to penetrate the substrate material, but rather were superficial fold of resolidified metal.

#### Metallographic Examination

Metallographic specimens were prepared through each of the Vericode patterns. One was polished to a plane which bisected the pattern parallel to the direction of laser travel and the other taken in a plane normal to that. Both specimens were mounted and polished for examination using standard metallographic techniques.

When viewed in the as-polished condition, only minor surface irregularity was observed. The maximum depth of apparent laser cutting was 0.0005 inch. In addition, no cracking was observed when inspected at magnifications up to 1000X.

Etching of the polished cross sections clearly revealed the recast layer in the marked areas. The maximum depth of the recast material was 0.0005 inch and the apparent heat affected depth was roughly 0.0017 inch. Refer to Figures 8 through 11 for typical examples.

#### SUMMARY

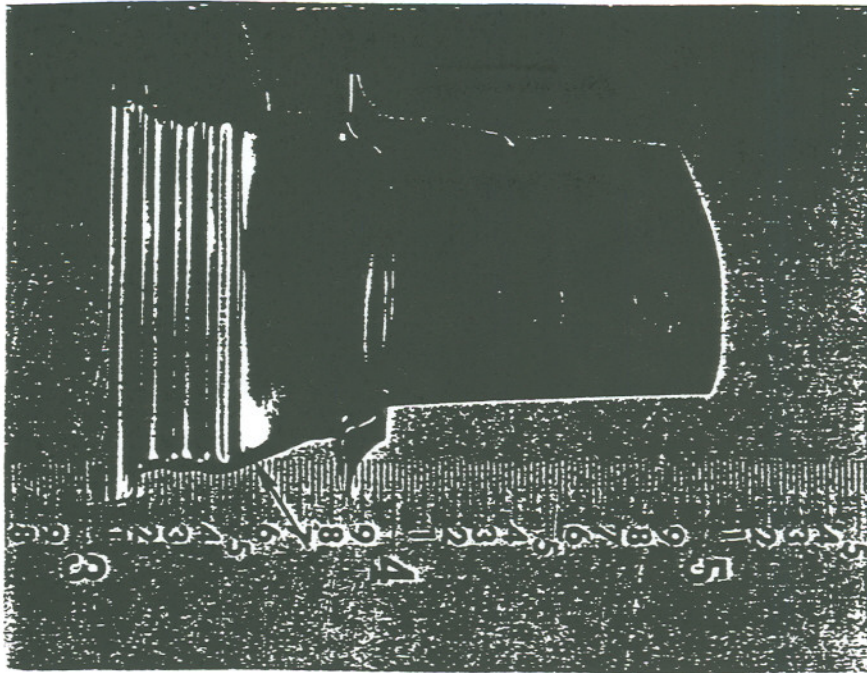
Vericode marking of the Mar-M-246 material using a laser appears to have resulted in very little disturbance of the parent material. The remelt depth and heat affected layer were both small, and no cracking was induced by the process.

SIGNED M. R. Leifeste DATE 9/28/82  
M. R. Leifeste, Engineering Specialist  
Materials & Processes Failure Analysis Laboratory

cc: L. Burgess  
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FILE

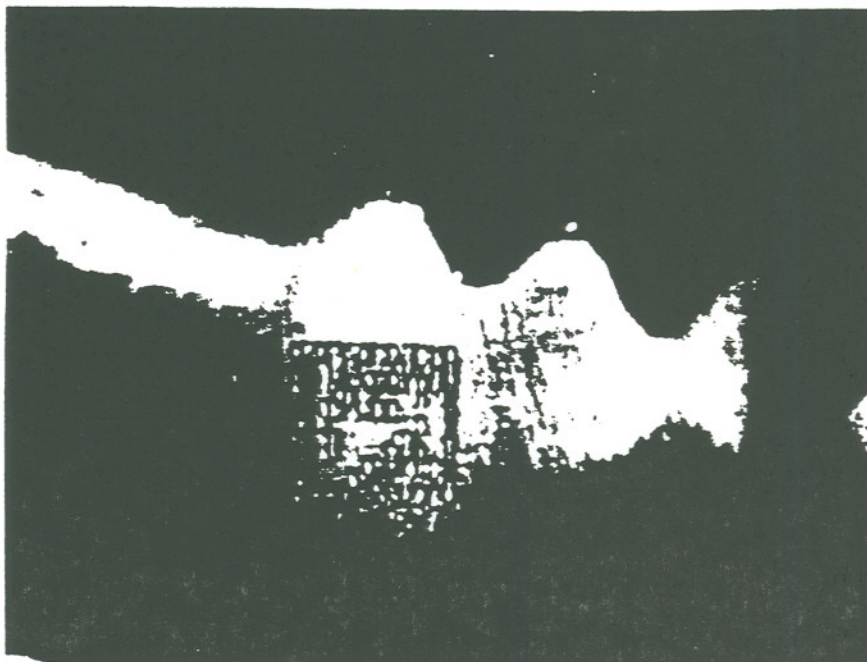


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1.6X

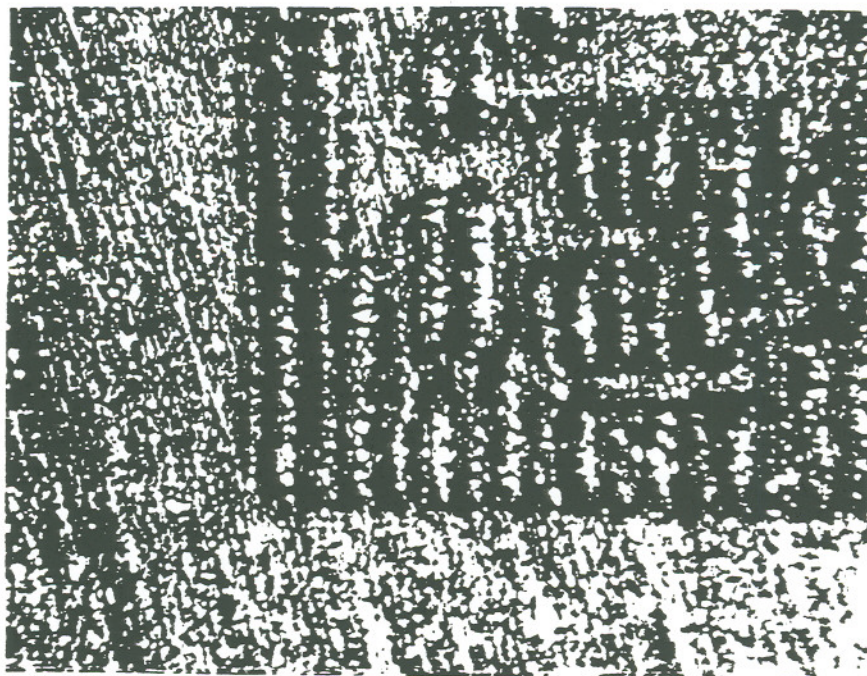
Figure 1. Overall view of the turbine blade segment with arrows showing the location of the two Vericode markings.



10X

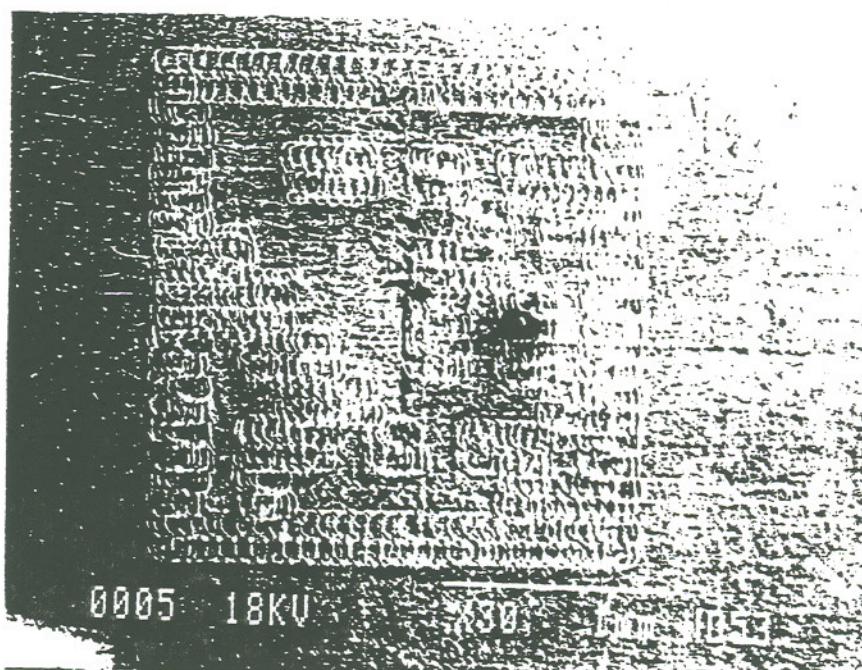
Figure 2. Optical photomacrograph of one of the Vericode markings.

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50X

Figure 3. Optical photomicrograph of a typical portion of the laser marked Vericode patterns.

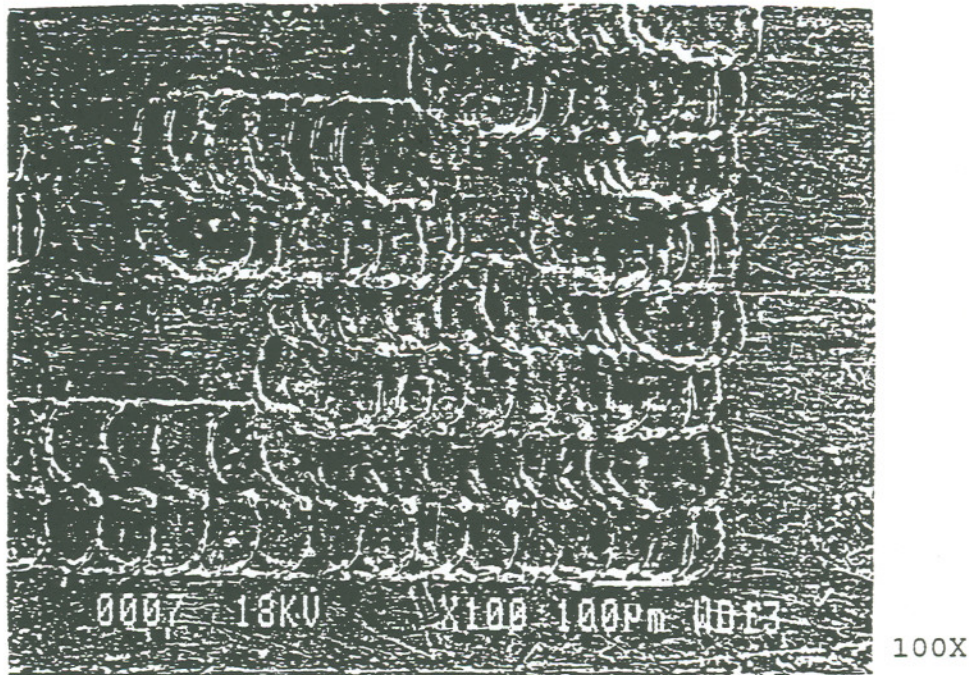


30X

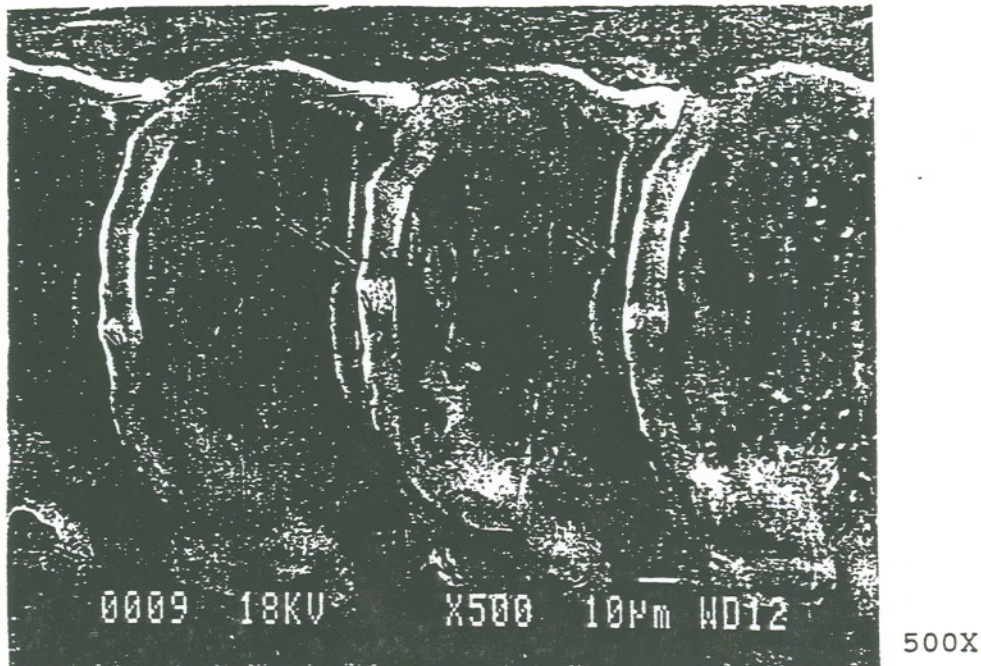
Figure 4. SEM photomicrograph of a typical laser marked Vericode pattern. The dark areas are SEM artifacts due to dirt.



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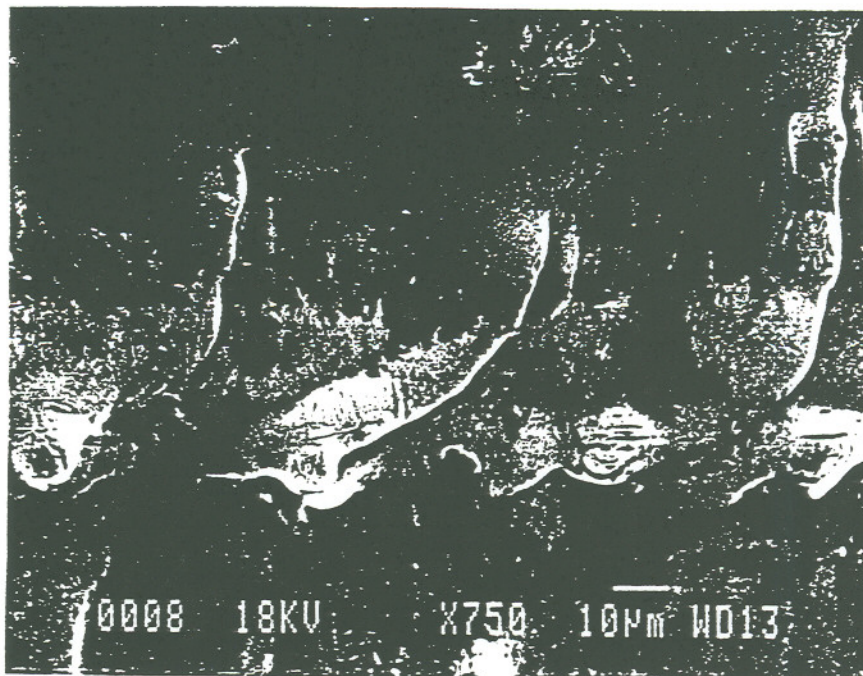
**Figure 5.** Higher magnification detail of a typical area of the Vericode patterns. The small melt craters created by the laser are readily apparent.



**Figure 6.** Higher magnification of the overlapping melt craters caused by the laser. Arrows locate small gaps along the edges of resolidified folds at the perimeter of the melt spots.

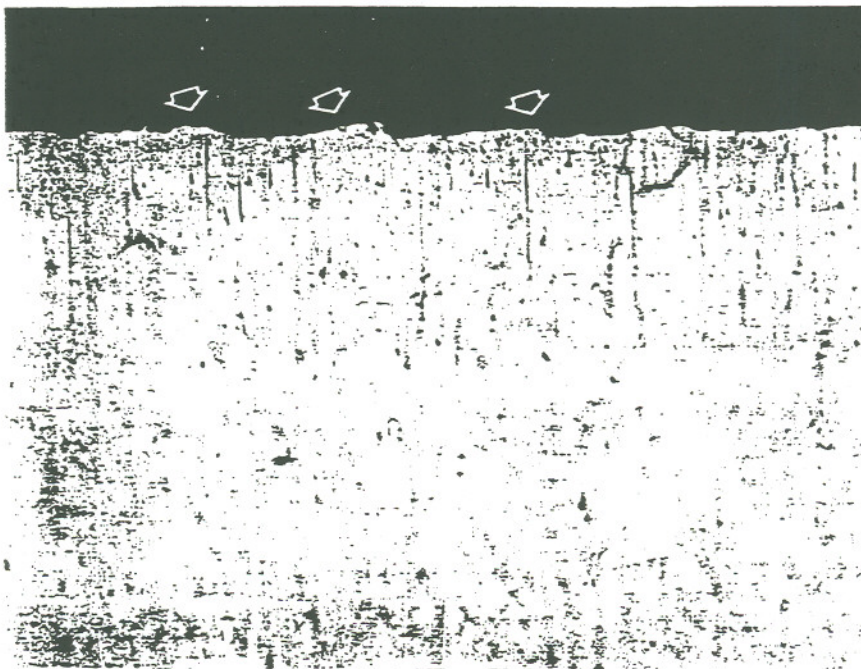


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750X

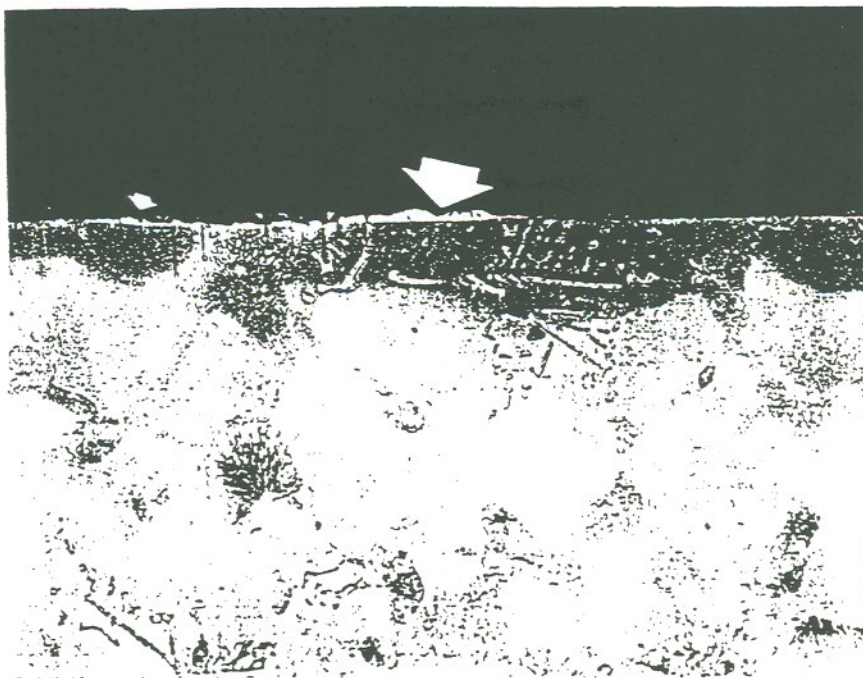
Figure 7. Another area of gaps along the resolidified folds at the edges of the melt spots.



200X

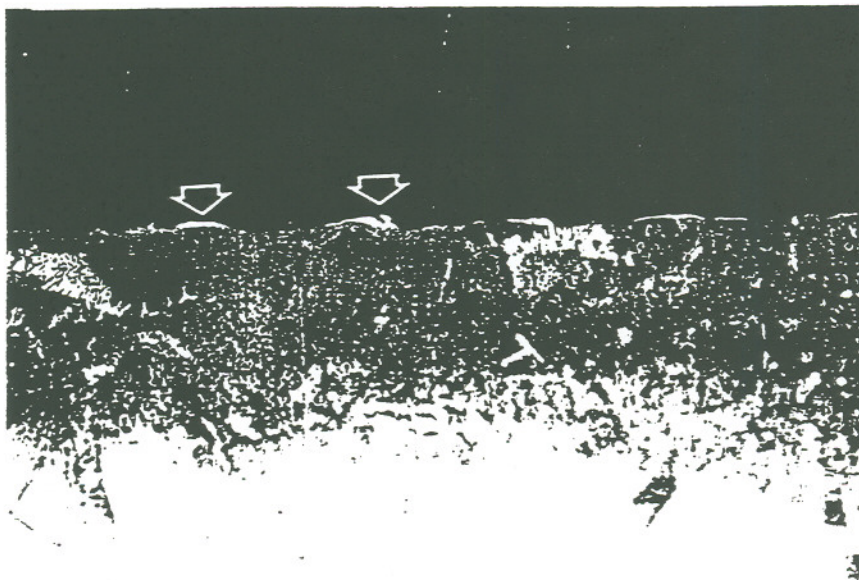
Figure 8. Metallographic cross section through one of the laser marked Vericodes. Arrows locate the slight surface irregularity caused by the marking process. No cracks are apparent.

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200X

Figure 9. Similar view to the previous figure after etching. The white areas (arrows) are resolidified metal. The dark areas are the heat affected region.

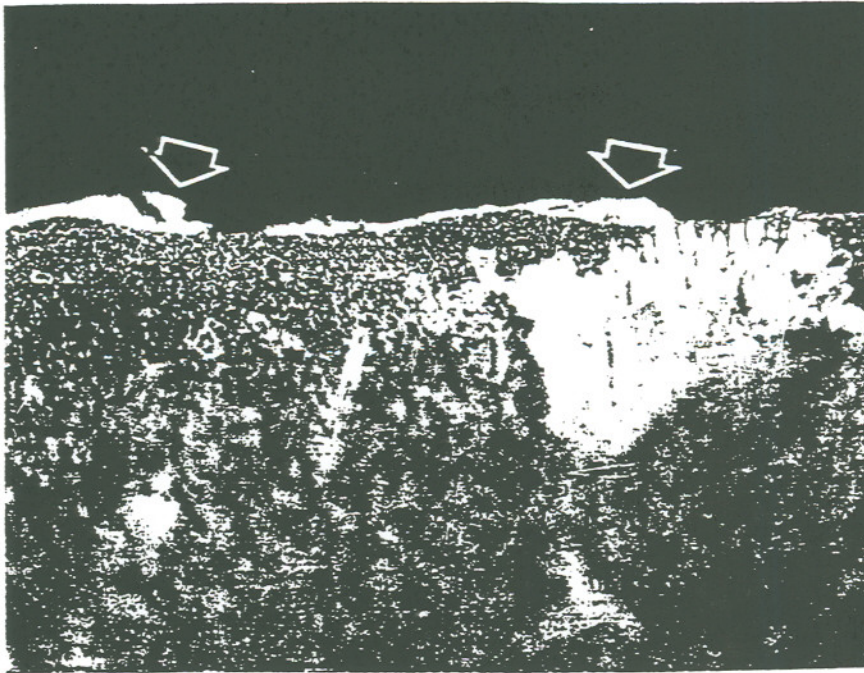


200X

Figure 10. Another area similar to the previous figure. Arrows indicated areas of limited molten/resolidified material.



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600X

Figure 11. Higher magnification of the typical resolidified material (arrows).